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SIGMA CONVERGENCE OF LABOUR PRODUCTIVITY ACROSS INDONESIAN PROVINCES, 2016–2025

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Abstract: *Labour productivity in Indonesia remains highly uneven across provinces: output per worker in DKI Jakarta is about sixteen times that of Nusa Tenggara Timur. This study examines whether these disparities narrowed between 2016 and 2025 by testing sigma convergence across 34 provinces. Labour productivity is measured as real Gross Regional Domestic Product at 2010 constant prices per employed person, using data from Statistics Indonesia (BPS) processed by the Ministry of Manpower. Dispersion is measured by the coefficient of variation (CV), and its change is evaluated with a linear trend regression and the Carree–Klomp test, supplemented by robustness checks that exclude outlying provinces. The CV was 0.767 in 2016 and 0.769 in 2025, with no significant trend ($p = 0.602$) and no significant change in log variance ($T_2 = 0.499$; $p = 0.480$); sigma convergence is therefore not found for Indonesia as a whole. A spike to 0.860 in 2023 reflects an exceptional value for Papua. When DKI Jakarta, Papua, and Papua Barat are excluded, the CV of the remaining 31 provinces falls significantly from 0.697 to 0.626 ($\delta = -0.0076$ per year; $p < 0.001$), although the decline has stalled since 2021. National dispersion is thus sustained by Jakarta's widening lead and by volatile data for Papua, while the least productive provinces in eastern Indonesia continue to lag. Policy should prioritise productivity-raising investment in lagging provinces and improve the consistency of provincial statistics after administrative splits.*

Keyword: *Coefficient of variation, Labour productivity, Regional disparity, Sigma convergence, Indonesia*

Abstrak: Produktivitas tenaga kerja di Indonesia masih sangat timpang antarprovinsi: output per pekerja di DKI Jakarta sekitar enam belas kali lipat dibandingkan dengan di Nusa Tenggara Timur. Studi ini mengkaji apakah kesenjangan tersebut menyempit antara tahun 2016 dan 2025 dengan menguji konvergensi sigma di 34 provinsi. Produktivitas tenaga kerja diukur sebagai Produk Domestik Regional Bruto (PDRB) riil atas dasar harga konstan tahun 2010 per orang yang bekerja, menggunakan data dari Badan Pusat Statistik (BPS) yang diolah oleh Kementerian Ketenagakerjaan. Dispersi diukur dengan koefisien variasi (CV), dan perubahannya dievaluasi menggunakan regresi tren linear serta uji Carree–Klomp, yang dilengkapi dengan pemeriksaan ketahanan (robustness check) dengan mengecualikan provinsi-provinsi yang menjadi pencilan (outlier). Nilai CV tercatat sebesar 0,767 pada tahun 2016 dan 0,769 pada tahun 2025, tanpa tren yang signifikan ($p = 0{,}602$) dan tanpa perubahan signifikan pada varians log ($T_2 = 0{,}499$; $p = 0{,}480$); dengan demikian, konvergensi sigma tidak ditemukan untuk Indonesia secara keseluruhan. Lonjakan ke angka 0,860 pada tahun 2023 mencerminkan nilai yang luar biasa untuk Papua. Ketika DKI Jakarta, Papua, dan Papua Barat dikecualikan, nilai CV dari 31 provinsi sisanya turun secara signifikan dari 0,697 menjadi 0,626 ($\delta = -0{,}0076$ per tahun; $p < 0{,}001$), meskipun penurunan tersebut terhenti sejak tahun 2021. Dengan demikian, dispersi nasional tetap bertahan karena keunggulan Jakarta yang kian melebar serta data Papua yang fluktuatif, sementara provinsi-provinsi dengan tingkat produktivitas terendah di wilayah timur Indonesia terus tertinggal. Kebijakan harus memprioritaskan investasi untuk meningkatkan produktivitas di provinsi-provinsi yang tertinggal serta memperbaiki konsistensi statistik provinsi

setelah adanya pemekaran wilayah administratif.

Kata kunci: Koefisien variasi, Produktivitas tenaga kerja, Kesenjangan regional, Konvergensi sigma, Indonesia

INTRODUCTION

Labour productivity, the average output produced by one worker in a given period, is a central indicator of a region's economic capability because it reflects the capital, technology, and skills available to its workforce. Neoclassical growth theory predicts that regions with low initial productivity should grow faster than advanced regions, because additional capital earns higher returns where it is scarce and because lagging regions can imitate technologies that already exist elsewhere (Solow, 1956). This catch-up process, formalised as convergence by Barro and Sala-i-Martin (1992), implies that regional disparities in output per worker should narrow over time. Once regions differ in their saving, schooling, and technology, however, each converges to its own steady state, so disparities can persist even when the catch-up mechanism operates (Mankiw et al., 1992).

Indonesia offers a demanding test of this prediction. In 2016, output per worker in DKI Jakarta reached IDR 316.74 million, whereas in Nusa Tenggara Timur it was only IDR 26.21 million, a ratio of about 12 to 1. By 2025, national labour productivity had risen from IDR 79.68 million to IDR 92.67 million per worker, yet the gap between the most and least productive provinces had widened to about 16 to 1. Such disparities matter because low productivity limits wages, fiscal capacity, and the ability of lagging provinces to move to a higher level of development.

Convergence can be examined in two complementary ways. Beta convergence asks whether initially poorer regions grow faster, whereas sigma convergence asks whether the cross-sectional dispersion of the variable actually declines over time. Beta convergence is a necessary but not sufficient condition for sigma convergence: new shocks can keep dispersion constant or even increase it while lagging regions are catching up (Sala-i-Martin, 1996; Young et al., 2008). Because a negative growth–initial level relationship can arise from regression toward the mean, several authors argue that the evolution of dispersion itself should be measured directly (Friedman, 1992; Quah, 1993). Sigma convergence is therefore the natural first step in assessing whether regional productivity gaps are closing.

Empirical evidence is mixed. Across Chinese provinces and production sectors, labour productivity shows both beta and sigma convergence (Bhattarai & Qin, 2022), whereas across 61 economies over 1995–2019, apparent labour productivity displays persistent polarisation into high- and low-productivity clusters (Brondino et al., 2025). Among Eurozone members, convergence in labour productivity slowed markedly after the 2008 financial crisis (Ortega-Díaz & Santillán-Salgado, 2024). In Indonesia, regional income dispersion first widened and then narrowed (Kurniawati, 2019); sectoral labour productivity converges across provinces once spatial effects are taken into account (Novianto & Marsisno, 2019); district-level labour productivity converged during 2010–2022 (Wahyuni, 2024); and convergence has also been examined within specific sectors and provinces (Nasution & Wahyuni, 2022).

Most Indonesian studies focus on beta convergence and use data that end before the post-pandemic recovery. Few test whether changes in dispersion are statistically significant, and few examine how sensitive the result is to a small

number of extreme provinces, notably DKI Jakarta and the Papua provinces, whose data changed after the 2022 administrative split. This study addresses these gaps by measuring sigma convergence of labour productivity across 34 provinces over 2016–2025, testing the hypothesis (H1) that the dispersion of labour productivity declines over time. It contributes by using the latest provincial data up to 2025, by formally testing the trend and significance of dispersion, and by identifying which provinces drive the national result, thereby providing a baseline for subsequent beta-convergence analysis and for regional productivity policy.

METHOD

This quantitative descriptive study uses secondary annual data for 34 Indonesian provinces over 2016–2025, giving 340 province-year observations. Labour productivity data were obtained from Statistics Indonesia (BPS), based on the August National Labour Force Survey (Sakernas) and processed by the Data and Information Centre of the Ministry of Manpower (Pusdatik Kemnaker), with Gross Regional Domestic Product (GRDP) figures taken from the BPS releases of February 2026 (Badan Pusat Statistik, 2026; Kementerian Ketenagakerjaan, 2026). Figures for 2023 and 2024 are preliminary and those for 2025 are very preliminary. To keep a balanced panel, the four provinces created in Papua in 2022 are kept within their parent provinces, Papua and Papua Barat. Labour productivity of province i in year t is defined in equation (1):

$$y_{i,t} = \frac{\mathrm{GRDP}_{i,t}}{L_{i,t}} \qquad 1)$$

where $\mathrm{GRDP}_{i,t}$ is real output at 2010 constant prices and $L_{i,t}$ is the number of employed persons, so that $y_{i,t}$ is expressed in million rupiah per worker. Following Barro and Sala-i-Martin (1992), sigma convergence is measured by the coefficient of variation (CV), which expresses the standard deviation of productivity relative to its cross-provincial mean, as shown in equation (2):

$$CV_t = \frac{\sqrt{\frac{\sum_{i=1}^{n}(y_{i,t}-\bar{y}_t)^2}{n}}}{\bar{y}_t} \qquad 2)$$

where $\bar{y}_t$ is the unweighted mean of labour productivity across provinces in year t and n = 34. Each province carries equal weight, so the CV measures disparity between provinces rather than between workers. A decline in the CV from one year to the next indicates convergence in that year, but year-on-year changes are sensitive to temporary shocks. The long-run direction of dispersion is therefore tested with the trend regression in equation (3):

$$CV_t = \alpha + \delta t + \varepsilon_t \qquad (3)$$

where t is a time trend (2016 = 0). H1 is accepted when δ is negative and significant at the 5 percent level, indicating sigma convergence; a positive or insignificant δ indicates no convergence.

$$T_2 = (N - 2.5)\ln\left[1 + \frac{(\sigma_1^2 - \sigma_T^2)^2}{4(\sigma_1^2\sigma_T^2 - \sigma_{1T}^2)}\right] \qquad (4)$$

where σ_1^2 and σ_T^2 are the cross-provincial variances of log labour productivity in 2016 and 2025, σ_{1T} is their covariance, and N is the number of provinces. Under the null hypothesis of no change in dispersion, T_2 follows a χ^2 distribution with one degree of freedom. The standard deviation of log labour productivity is also reported as an alternative dispersion measure that is less dominated by high values. To assess robustness, all tests are repeated after excluding DKI Jakarta, whose productivity is about four times the

provincial mean; Papua and Papua Barat, whose 2023 values are exceptional; and all three provinces. Calculations were performed in Microsoft Excel and Python.

RESULTS AND DISCUSSION

Results

Labour productivity and its dispersion

Table 1 summarises the distribution of labour productivity across the 34 provinces.

The unweighted mean rose from IDR 85.63 million per worker in 2016 to IDR 106.68 million in 2025, but the standard deviation rose almost in proportion, from 65.70 to 82.01. Nusa Tenggara Timur recorded the lowest productivity in every year, while DKI Jakarta recorded the highest in every year except 2023, when Papua's value jumped to IDR 420.89 million before falling back to IDR 112.44 million in 2024. The ratio of the highest to the lowest provincial value widened from 12.09 in 2016 to 16.05 in 2025.

Table 1 Dispersion of labour productivity across 34 provinces, 2016–2025.

Year	Mean	SD	CV	ΔCV	SD of ln *y*	Max/min	Year-on-year status
2016	85.63	65.70	0.767	–	0.560	12.09	–
2017	90.15	70.54	0.782	+0.015	0.551	13.41	Divergence
2018	90.34	70.82	0.784	+0.002	0.561	14.65	Divergence
2019	92.57	71.90	0.777	−0.007	0.555	14.26	Convergence
2020	90.74	71.28	0.786	+0.009	0.555	15.24	Divergence
2021	92.08	71.78	0.780	−0.006	0.551	15.60	Convergence
2022	94.50	73.31	0.776	−0.004	0.552	16.07	Convergence
2023*	110.55	95.08	0.860	+0.084	0.647	16.20	Divergence
2024*	101.51	77.91	0.768	−0.093	0.577	16.30	Convergence
2025**	106.68	82.01	0.769	+0.001	0.584	16.05	Divergence

Source: BPS and Kemnaker, processed by the author. Mean and SD in IDR million per worker. * preliminary; ** very preliminary.

Sigma convergence across 34 provinces

The CV was 0.767 in 2016 and 0.769 in 2025, essentially unchanged over the decade (Figure 1). Year-on-year, dispersion fell in 4 of the nine transitions (2019, 2021, 2022, and 2024) and rose in 5 (2017, 2018, 2020, 2023, and 2025). The largest movements occurred in 2023, when the CV jumped to 0.860, and in 2024, when it returned to 0.768; both reflect the exceptional value for Papua rather than a change across the distribution as a whole.

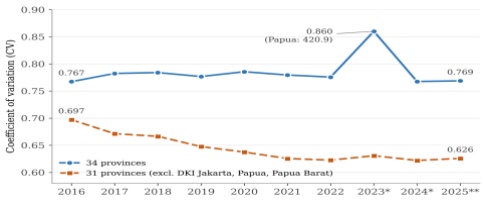

Fig. 1 Coefficient of variation of labour productivity, 2016–2025. * preliminary; ** very preliminary.

The trend regression confirms the absence of convergence. The trend coefficient for the full sample is positive but insignificant (δ = 0.0017; SE = 0.0031; p = 0.602; R^2 = 0.036), and the Carree–Klomp test shows no significant change in log variance between 2016 and 2025 (T_2 = 0.499; p = 0.480). The standard deviation of log productivity even rose slightly, from 0.560 to 0.584. Therefore, H1 is rejected: labour productivity across Indonesia's 34 provinces did not undergo sigma convergence during 2016–2025.

Robustness checks

Table 2 shows how the result changes when outlying provinces are excluded. Removing Papua and Papua Barat eliminates the 2023 spike, but the

CV stays almost flat (0.798 in 2016 and 0.803 in 2025; p = 0.269). Removing DKI Jakarta lowers the CV from 0.671 to 0.607, a fall of about 9.5 percent, but the 2023 spike to 0.801 keeps the trend insignificant (p = 0.874).

Table 2 Trend and Carree–Klomp tests of sigma convergence by sample, 2016–2025.

Sample	*n*	CV 2016	CV 2025	δ (SE)	p-value	T_2 (p-value)	Conclusion
34 provinces (full sample)	34	0.767	0.769	0.0017 (0.0031)	0.602	0.499 (0.480)	No sigma convergence
Excluding Papua and Papua Barat	32	0.798	0.803	−0.0009 (0.0008)	0.269	0.303 (0.582)	No sigma convergence
Excluding DKI Jakarta	33	0.671	0.607	−0.0012 (0.0071)	0.874	0.222 (0.638)	No sigma convergence
Excluding DKI Jakarta, Papua, and Papua Barat	31	0.697	0.626	−0.0076 (0.0013)	< 0.001	0.072 (0.788)	Sigma convergence

Source: BPS and Kemnaker, processed by the author. δ is the annual trend in the CV (equation 3); T_2 is the Carree–Klomp statistic on log labour productivity (equation 4), $\chi^2(1)$.

Only when DKI Jakarta, Papua, and Papua Barat are all excluded does a clear pattern of sigma convergence emerge. The CV of the remaining 31 provinces declined steadily from 0.697 in 2016 to 0.625 in 2021 and ended at 0.626 in 2025, a fall of 10.2 percent; the negative trend is highly significant (δ = −0.0076; p < 0.001; $R^2 = 0.804$).

Two qualifications apply. First, the decline is concentrated in 2016–2021; since 2021 the CV has fluctuated around 0.62–0.63 without a further downward trend. Second, the standard deviation of log productivity for the same 31 provinces did not fall (0.501 in 2016 and 0.511 in 2025), and the Carree–Klomp test is insignificant (T_2 = 0.072; p = 0.788).

Because the CV gives more weight to high values while the log measure is more sensitive to the bottom of the distribution, this combination suggests that convergence among the 31 provinces came mainly from slower growth at the top rather than from faster growth at the bottom.

Provincial growth patterns

Table 3 compares selected provinces to identify which movements drive these results. DKI Jakarta grew by 3.69 percent a year, faster than the provincial mean, so its productivity relative to the mean rose from 3.70 times in 2016 to 4.14 times in 2025. The other high-productivity provinces, which are rich in mining, oil and gas, or industrial activity, grew slowly at about 1 percent a year or less, narrowing their distance from the mean.

At the bottom, Nusa Tenggara Timur, Maluku, and Nusa Tenggara Barat grew at about 1 percent a year or less, and Nusa Tenggara Barat even declined. Maluku Utara and Sulawesi Tengah recorded the fastest growth, at 10.59 and 8.93 percent a year.

Across all provinces, the correlation between initial log productivity and subsequent growth is close to zero (r = −0.046), so there is no simple sign that low-productivity provinces as a group grew faster.

Table 3 Labour productivity of selected provinces, 2016 and 2025 (IDR million per worker).

Group	Province	2016	2025**	Average growth (% per year)
Highest initial level	DKI Jakarta	316.74	441.31	3.69
	Kalimantan Timur	277.63	302.91	0.97
	Kepulauan Riau	189.41	213.41	1.33
	Kalimantan Utara	186.76	200.93	0.81
	Riau	165.86	186.43	1.30
Lowest initial level	Nusa Tenggara Timur	26.21	27.49	0.53
	Maluku	38.05	42.18	1.14
	Nusa Tenggara Barat	39.93	36.35	−1.04
	Bengkulu	41.53	51.17	2.32
	DI Yogyakarta	42.93	59.74	3.67
Fastest growth	Maluku Utara	42.82	111.05	10.59
	Sulawesi Tengah	62.35	139.31	8.93
	Mean of 34 provinces	85.63	106.68	2.44

Source: BPS and Kemnaker, processed by the author. Average growth is the annual log change over 2016–2025. ** very preliminary.

Discussion

The absence of sigma convergence across the 34 provinces is consistent with evidence that apparent labour productivity tends to remain polarised rather than to converge (Brondino et al., 2025), and with the stalling of productivity convergence observed among Eurozone members after a major shock (Ortega-Díaz & Santillán-Salgado, 2024). It contrasts with the joint beta and sigma convergence found across Chinese provinces (Bhattarai & Qin, 2022) and with the eventual narrowing of regional income dispersion in Indonesia (Kurniawati, 2019). The result does not necessarily contradict evidence of beta convergence in Indonesian labour productivity (Novianto & Marsisno, 2019; Wahyuni, 2024): as convergence theory emphasises, lagging regions may be catching up while new shocks and the continued advance of the leading region keep overall dispersion constant (Sala-i-Martin, 1996; Young et al., 2008).

The robustness checks show that national dispersion is sustained by two different forces. The first is DKI Jakarta. Its productivity grew faster than the provincial mean, so its lead widened throughout the period. This is consistent with the role of capital deepening and technology in determining each region's steady state (Mankiw et al., 1992): as a centre of finance, services, and high-value activities, Jakarta continues to accumulate the physical capital, skills, and digital infrastructure that raise output per worker. The second is the instability of the Papua data. Papua's productivity rose to IDR 420.89 million per worker in 2023 and fell back to IDR 112.44 million in 2024, and Papua Barat shows a similar but smaller jump. A temporary windfall in the extractive sector may contribute, but a swing of this size within one year also suggests that output and employment may not have been aggregated over the same territory after the 2022 provincial split. These values should therefore be interpreted with caution and checked against revised BPS releases.

Among the remaining 31 provinces, dispersion fell mainly because the high-productivity resource and industrial provinces, such as Kalimantan Timur, Kalimantan Utara, Riau, and Kepulauan Riau, grew slowly, consistent with diminishing returns where capital is already abundant. Rapid gains in Maluku Utara and Sulawesi Tengah, which likely reflect the expansion of nickel processing, also moved two provinces from below to above the mean. However, the least productive provinces in eastern Indonesia, including Nusa Tenggara Timur, Nusa Tenggara Barat, and Maluku, barely

improved, and the log-based measure shows no narrowing at the bottom of the distribution. This pattern points to a risk that these provinces are trapped at low productivity, which neoclassical theory would attribute to differences in physical capital, human capital, and technology rather than to the absence of a catch-up mechanism.

Three policy implications follow. First, reducing regional productivity disparities requires more than aggregate growth: physical investment, education, and digital infrastructure need to be directed to provinces with persistently low productivity, especially in Nusa Tenggara and Maluku. Second, productivity gains from resource-based downstream processing are concentrated in a few provinces and should be complemented by linkages that spread their benefits to neighbouring regions. Third, BPS and the Ministry of Manpower should ensure that output and employment data remain consistent after administrative splits, so that regional productivity can be monitored reliably.

This study has several limitations. The CV treats each province equally regardless of its employment size, and the 2023–2025 data are still preliminary. Sigma convergence describes the evolution of dispersion but does not explain its causes. Future research should therefore test absolute and conditional beta convergence with dynamic panel methods, controlling for gross fixed capital formation, mean years of schooling, and ICT development, and should examine the four new Papua provinces once consistent data become available.

CONCLUSION

This study finds no sigma convergence of labour productivity across Indonesia's 34 provinces during 2016–2025. The coefficient of variation was 0.767 in 2016 and 0.769 in 2025, with a temporary spike to 0.860 in 2023, and neither the trend regression nor the Carree–Klomp test indicates a significant decline in dispersion. The result is driven by the widening lead of DKI Jakarta and by unstable data for Papua and Papua Barat. Among the remaining 31 provinces, dispersion declined significantly from 0.697 to 0.626, but the decline stalled after 2021 and came mainly from slower growth among high-productivity provinces, while the least productive provinces in eastern Indonesia continued to lag. Narrowing regional productivity gaps therefore requires targeted investment in physical capital, education, and digital infrastructure in lagging provinces, together with consistent regional statistics. Subsequent beta-convergence analysis is needed to determine whether, and under what conditions, lagging provinces are catching up.

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